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(54) Optical fibre system

(57) A data transmission system uses a single optical fibre highway (4) for data transmission on a bi-directional basis. The two directions of transmission are separated on a bi-directional basis, and each terminal only has one light detector (7), which is so coupled to the highway via optical couplers (2, 3, 1) that it can receive light from either direction. The central circuitry (8) of the terminal is also connected to a light source (6), which supplies light for an outgoing message to both directions. The timings are such that messages can pass simultaneously in both directions through the highway, being interlaced in time when arriving at each terminal's receiver. Each message traversing the system is regeneratively repeated at each station via which it travels.

Two of the couplers (2, 3) are also connected via a low-loss bypass (10) which is normally disabled, but is rendered effective when the terminal fails, so that continuity is maintained.

In a second version of the system, separate light sources are provided for the two directions of transmission and continuity is maintained if a terminal fails via an attenuator between that terminal's optical couplers.

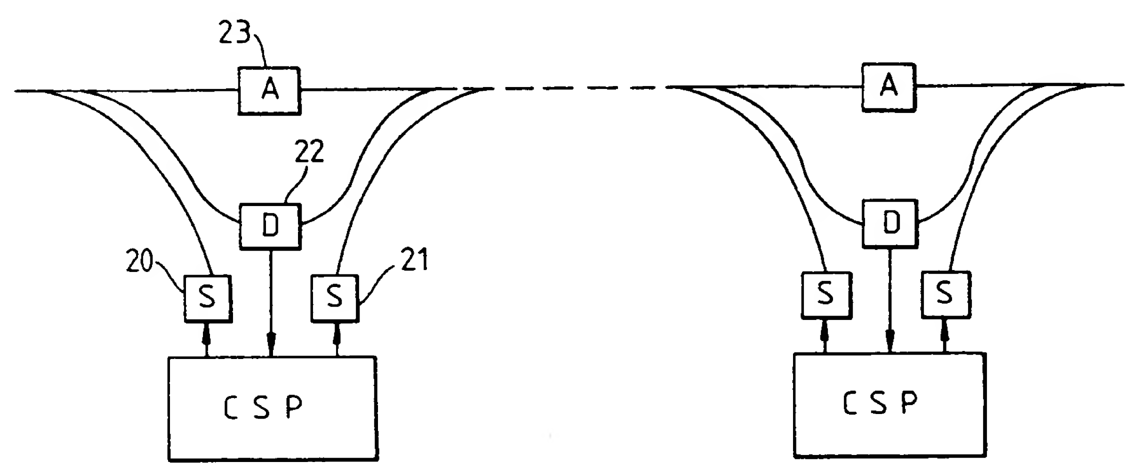

Fig.3.

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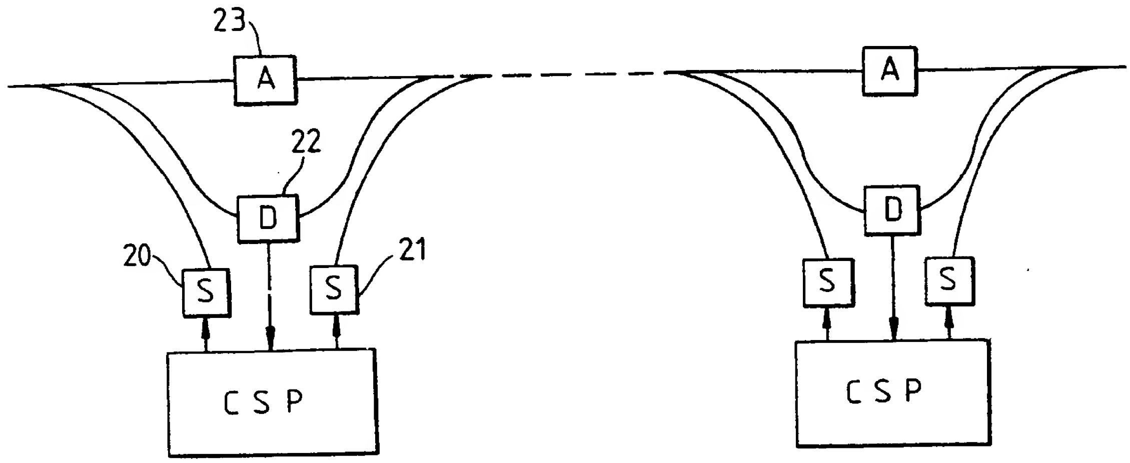

Fig. 3.

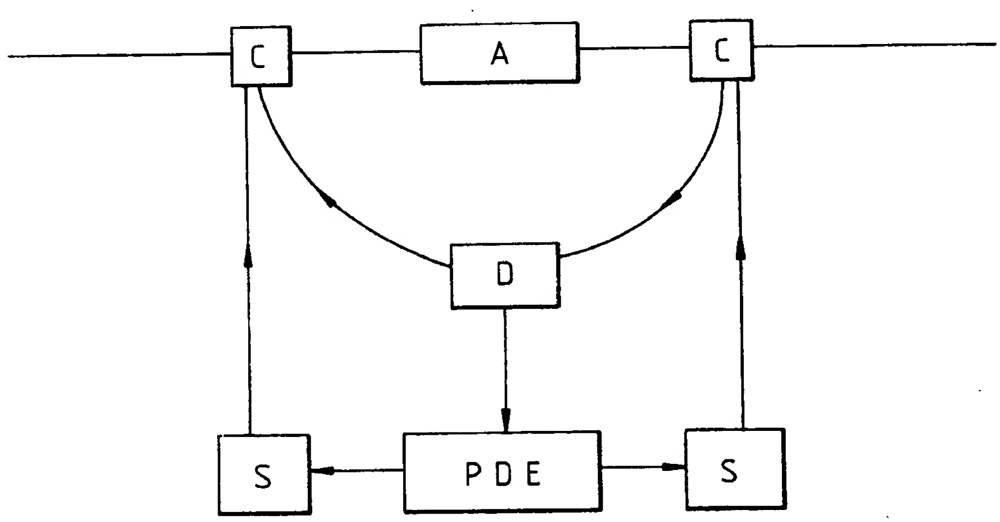

Fig. 4.

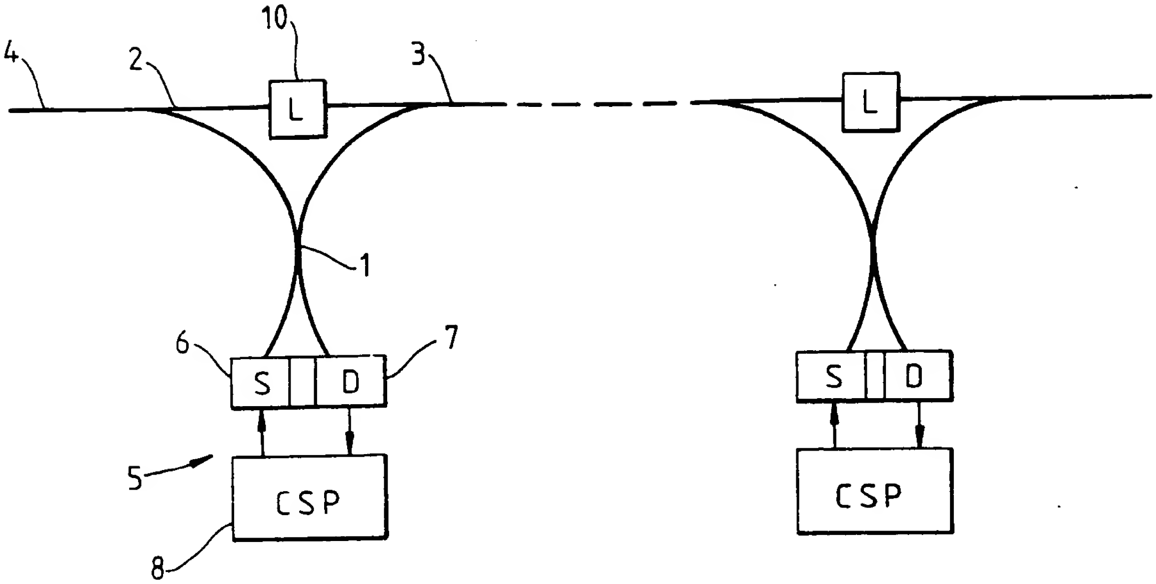

Fig .1.

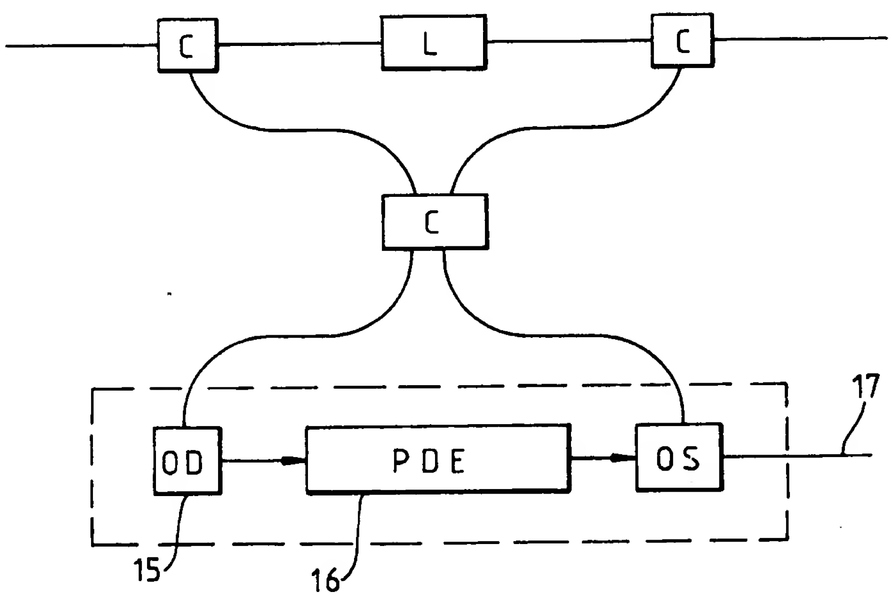

Fig .2.

SPECIFICATION
Optical fibre system

The present invention relates to a high speed data transmission system of the type in which the transmission medium is optical fibre.

According to the present invention there is provided a data transmission system in which data is transmitted via a single optical fibre bus to which is connected a plurality of data terminals, in which the same optical fibre bus is used for transmission in both directions by the use of time division multiplex techniques, and in which each said data terminal includes a single detector to which incoming light from the fibre is applied from whichever of the two directions of transmission is currently in use, the light reaching the detector from the two directions of transmission being synchronously interlaced in time.

Embodiment of the invention will now be described with reference to the accompanying highly schematic drawing, in which

Fig. 1 shows two stations of a first system embodying the invention,

Fig. 2 shows in slightly more detail a terminal as used in the system of Fig. 1,

Fig. 3 shows two stations of a second system embodying the invention, and

Fig. 4 shown in slightly more detail a terminal as used in the system of Fig. 3.

In the system embodying the present invention, the communication medium is bidirectional, and it uses a single optical fibre over which any data terminal can communicate with any other terminal in the system, regardless of location. The system can be of the closed loop type, but is not so limited. The terminals served are distributed along the data bus formed by the optical fibre, and are connected thereto by passive optical couplers. Each data terminal includes only one detector, which can receive data transmissions from either of two directions, and either one or two optical transmitters, depending on the coupling configuration. The optical detectors can be opto-transistors, and the transmitters may be light-emitting diodes (LED's) or lasers. Preferably the optical elements and the associated opto-electrical parts are incorporated into an integrated optical component.

Communication between data terminals is effected by the transmitting terminal inserting its message via the appropriate optical coupler on to the optical fibre highway. At the next terminal the message is passed from the highway by branching that message off via that next terminal's optical coupler. After a delay, whose duration depends on the terminal's characteristics, that terminal re-transmits the message along the highway, after which it adds its own message if it has one to send. When a message reaches its intended destination, as indicated by the message address, that message is absorbed and not re-transmitted.

Thus by regenerative repeating, messages traverse the bus (highway), each to its intended destination. That part of the signal on the highway which is not branched out of the highway, and thus not regenerated, is attenuated to below the detection threshold of subsequent terminals.

As a consequence of the use of a single optical fibre for bidirectional transmission is the fact that messages retransmitted to subsequent terminals are also returned or reflected, dependent on the coupling configuration, to the adjacent terminals from which they were previously received. To avoid data corruption, it is necessary to ensure that such unwanted signals are not received simultaneously with valid signals. By careful choice of inter-message periods and terminal delays it is possible to synchronously interlace all of the signals, sent and received, at each terminal to avoid such unwanted coincidences of signals.

Since the terminals are separated from the optical highway by the optical couplers, if one or more non-adjacent terminals fail, the remaining terminals can resynchronise and increase their optical output if necessary to continue satisfactory operation.

We now refer to Fig. 1, which shows two stations only of a system in which each terminal is connected to a four-port optical X coupler such as 1, which is in turn connected to two three-port optical Y couplers 2, 3 to provide access between the highway 4 and the terminal 5.

Each terminal such as 5 includes an optical source 6, from which outgoing messages are transmitted, and an optical detector 7 for the reception of incoming messages. The source, in fact, via the couplers shown, causes the message to be sent in both directions over the highway 4. The terminal also includes control and signal processing circuitry 8 associated with the source 6 and detector 7. If a terminal fails, automatic switching causes a low-loss by-pass connection 10 to be enabled, so that operation of the system can then continue.

Fig. 2 shows a data terminal as used in Fig. 1 in rather more detail. This terminal includes an optical detector 15, fast detector electronics 16 and an optical source 17. The block 16 responds to a message's address to remove it from the loop if it is intended for that block's own terminal. In addition, if it is not so intended it causes the message to be sent from the source OS via the X coupler and the Y coupler, to the highway. As already indicated, in this case, the outgoing signal is sent in *both* directions along the highway. An incoming message, in whichever direction it arrives, passes in via two couplers and the optical detector 15 to the electronics 16.

In the system shown in Fig. 3, each terminal has two optical sources 20, 21, one for transmission in each direction, with only one detector 22. Hence each source directs its transmissions at only one receiver. With this system, the two "sides" of an optical terminal are coupled by attenuator 23, the function of which is to attenuate these signals which have been propagated via more than one interterminal fibre link without regenerative repeating, and also to attenuate unwanted reflection.

When a terminal, in the system of Fig. 3, fails it is not necessary to switch that terminal out of the network. The transmitters at the terminals adjacent to the failed terminal merely increase their launched power to accommodate the increased optical loss due to the presence of the attenuator 23 in the signal path of the terminal.

Fig. 4 shows a data terminal for the system of Fig. 3 in more detail; in view of what has been said above it is felt that no detailed description of this figure is needed.

The main features of the system described herein are as follows:—

(a) a bidirectional data bus is provided using a single fibre;

(b) each terminal has a passive by-pass under fault conditions;

(c) efficient data transmission is accomplished, even at many high data bit rates;

(d) each terminal only needs one optical receiver;

(e) the optical detectors — each in a receiver — all have the same thresholds, so that replication of receiver circuitry is facilitated;

(f) the system can accommodate the failure of one or more terminals;

(g) if the ends of the highway are interconnected to form a ring, the system can be made tolerant to the failure of one inter-terminal fibre link.

Dependent on the applications of the invention the messages to be conveyed will each consist of one bit or more than one bits. Thus in a remote monitoring or control system the message proper could be a single bit when reporting the condition of a single device, or when controlling a change of state of such a device.

CLAIMS

1. A data transmission system in which data is transmitted via a single optical fibre bus to which is connected a plurality of data terminals, in which the same optical fibre bus is used for transmission in both directions by the use of time division multiplex techniques, and in which each said data terminal includes a single detector to which incoming light from the fibre is applied from whichever of the two directions of transmission is currently in use, the light reaching the detector from the two directions of transmission being synchronously interlaced in time.

2. A system as claimed in claim 1, in which each said terminal includes a first Y optical coupler interconnecting the terminal and the optical fibre to the terminal on one side and a second Y optical coupler interconnecting the terminal and the optical fibre to the terminal on the other side, in which the two Y couplers are also interconnected via a low-loss optical by-pass device which is normally disabled but which is enabled when the terminal fails, and in which the Y optical couplers are also connected to an X optical coupler which gives access to a light source for emitting messages to line and that terminal's single detector for receiving messages from the line.

3. A system as claimed in claim 1, in which each said terminal includes a first optical coupler via which the terminal is coupled to the optical fibre to the terminal on one side and a second optical coupler via which the terminal is coupled to the optical fibre to the terminal on the other side, in which the two optical couplers are interconnected via an optical attenuator via which continuity is maintained if the terminal fails, in which both said couplers give access to the said single detector for reception of messages from either side, and in which separate light sources for message emission are coupled to line via respective ones of said couplers for message emission in respective different direction.

4. A data transmission system, substantially as described with reference to Figs. 1 and 2, or Figs. 3 and 4, of the accompanying drawings.

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